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Suzuki

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(54) **LIQUID DEVELOPER SUPPLY DEVICE, DEVELOPING DEVICE, AND IMAGE FORMING APPARATUS**

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(52) **U.S. Cl.**
CPC ***G03G 15/104*** (2013.01)

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USPC 399/237, 238; 101/425
See application file for complete search history.

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(57) **ABSTRACT**

Provided is a liquid developer supply device including a supply roller that rotates and holds liquid developer in a recessed portion formed in an outer circumferential surface to supply the liquid developer to a receiving member, a liquid developer supply unit that supplies liquid developer between a seal member which is in contact with the supply roller on an upstream side in a rotating direction and a regulation member which is in contact with the supply roller on a downstream side, and that forms a liquid developer reservoir, and a supply unit that supplies a cleaning liquid to a contact portion from an upstream side of the contact portion between the supply roller and the seal member, in the rotating direction of the supply roller, such that the cleaning liquid flows down along the seal member due to gravity.

20 Claims, 10 Drawing Sheets

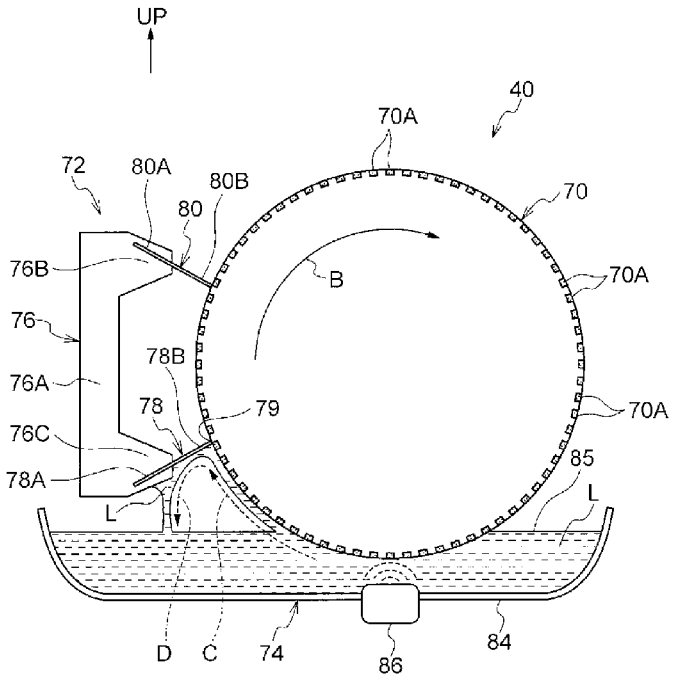
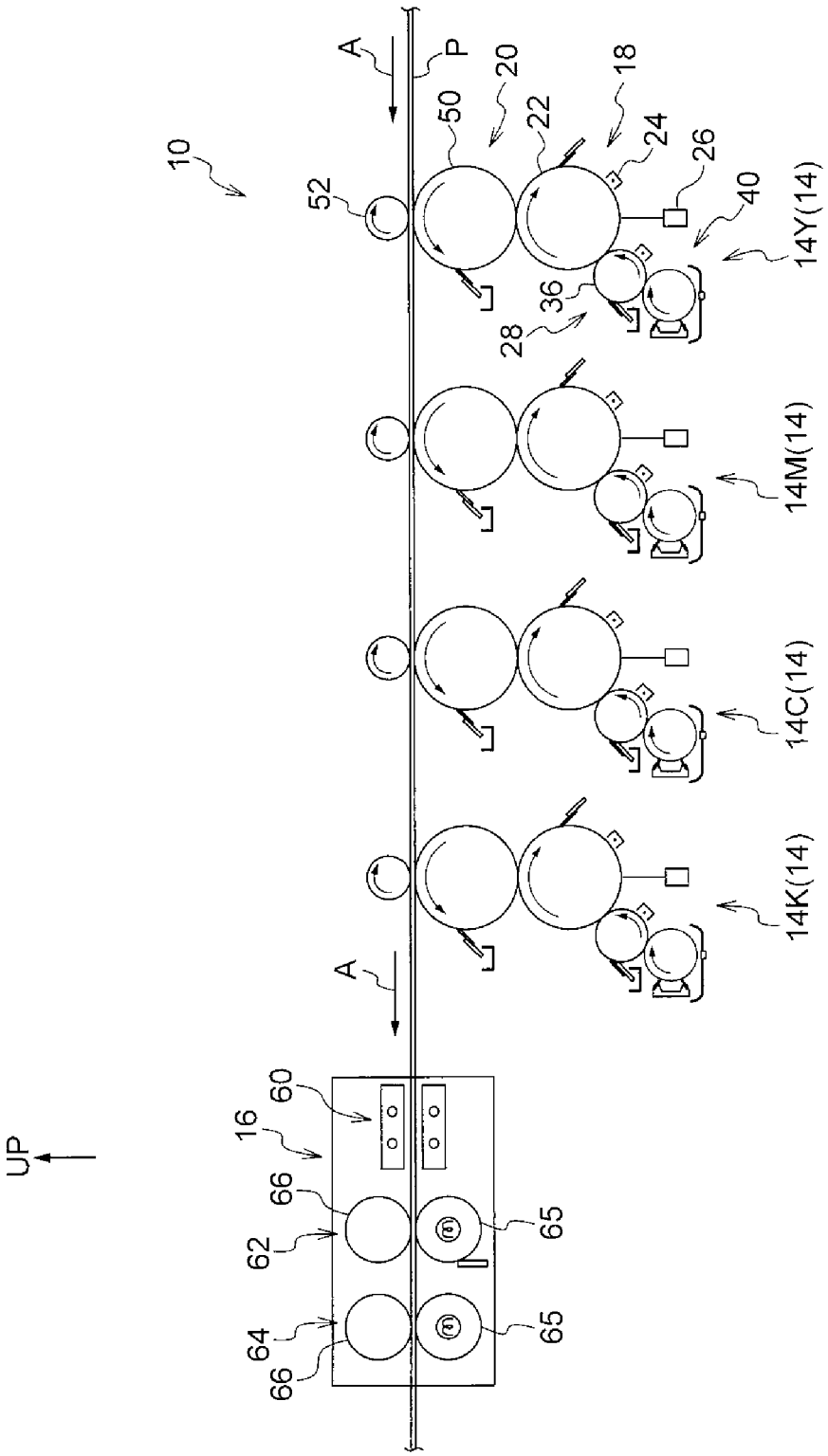


FIG. 1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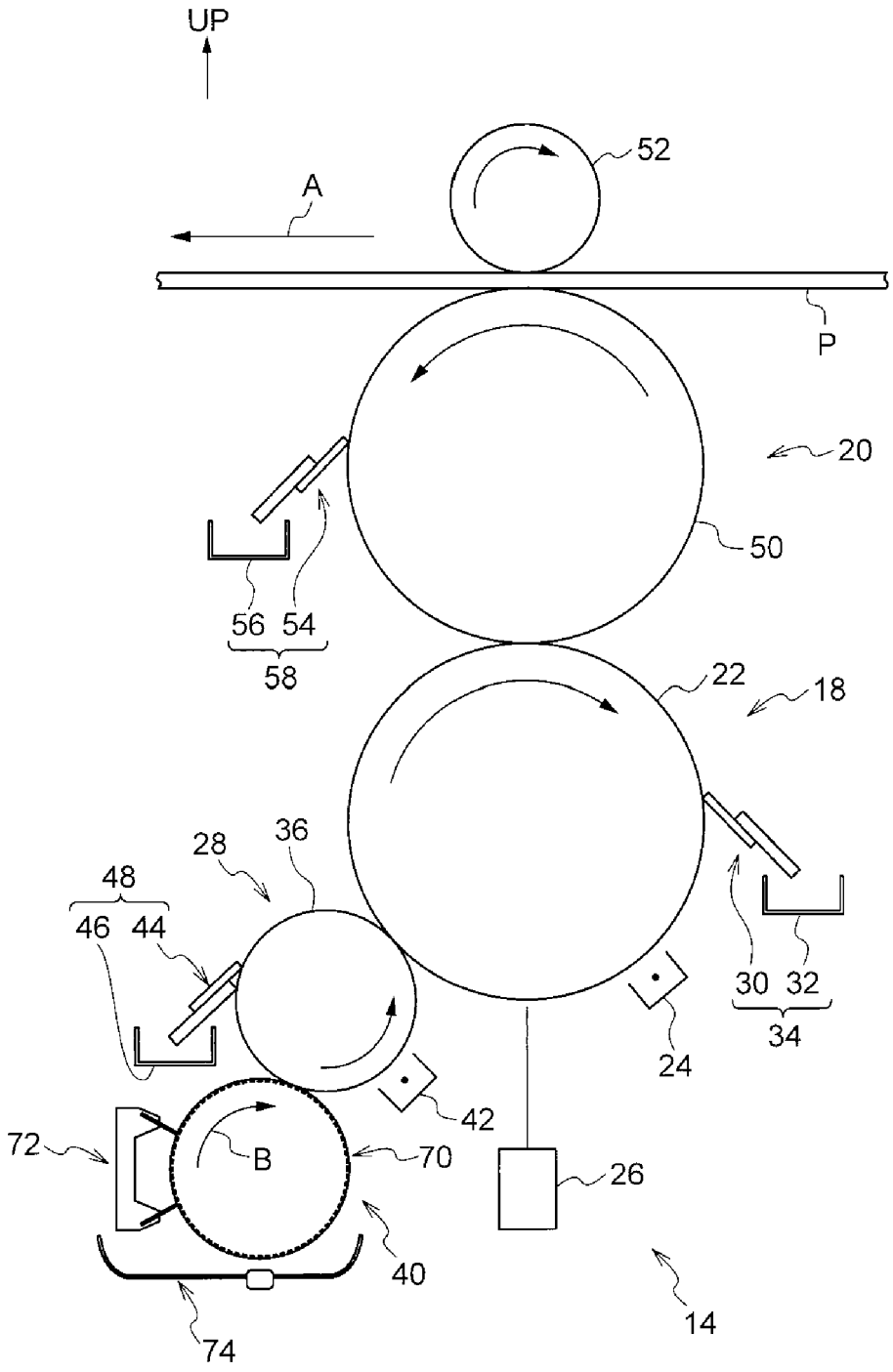
A
P
10
16
18
20
22
24
26
28
36
40
50
52
60
62
64
65
66
14Y(14)
14M(14)
14C(14)
14K(14)

FIG. 2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A
52
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50
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58
22
18
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48
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44
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32
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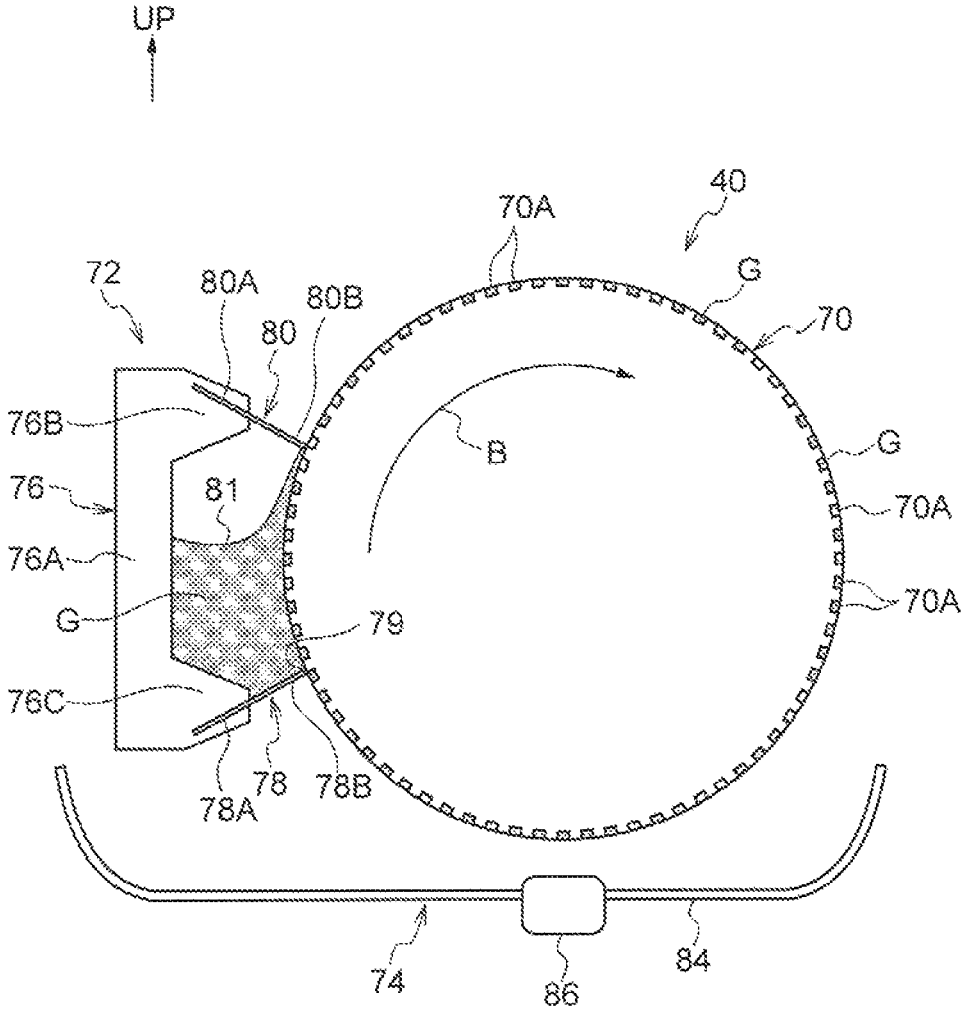
24
42
72
B
70
26
40
14
74

FIG. 3


UP
40
70A
72
80A
80B
80
G
70
76B
B
G
76
81
70A
76A
70A
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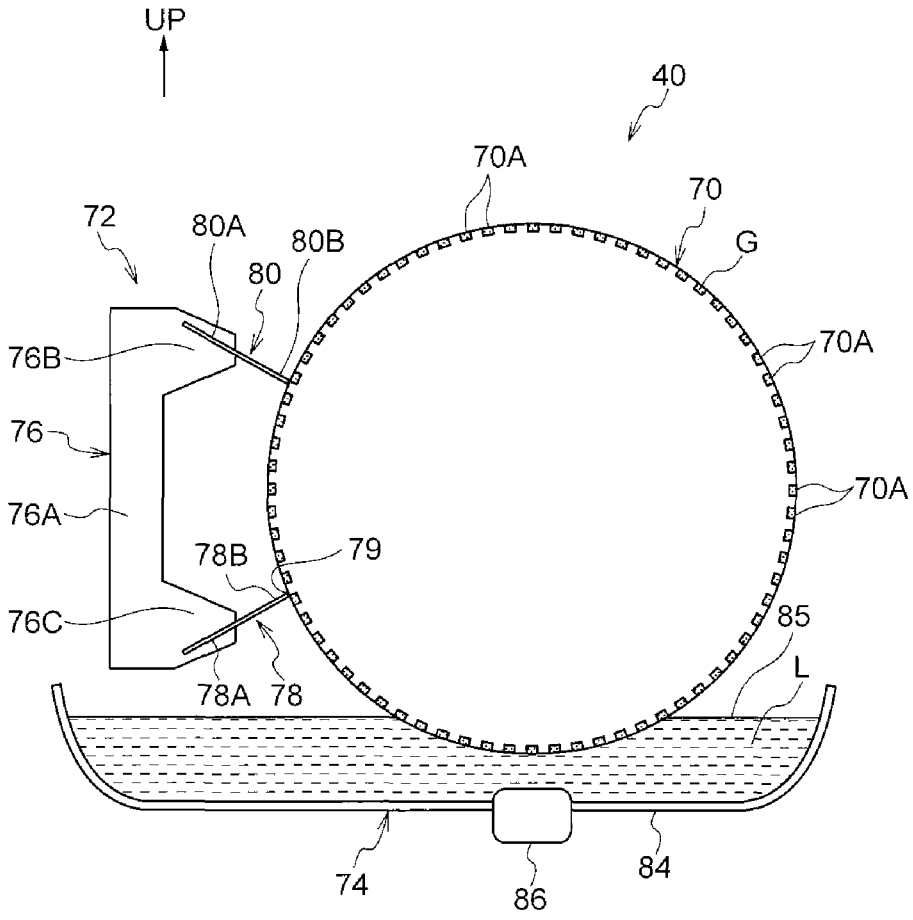
79
76C
78
78A
78B
74
86
84

FIG. 4


UP
40
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76C
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L
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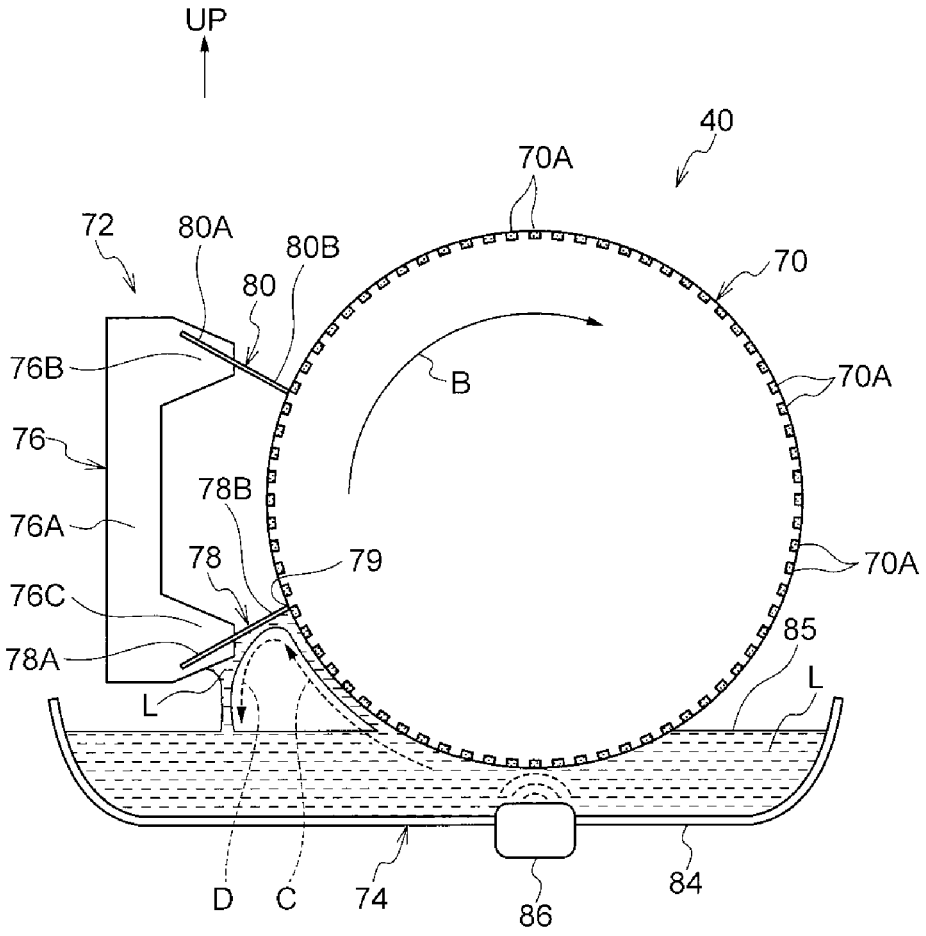
78
74
86
84

FIG. 5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40
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80
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76B
B
70A
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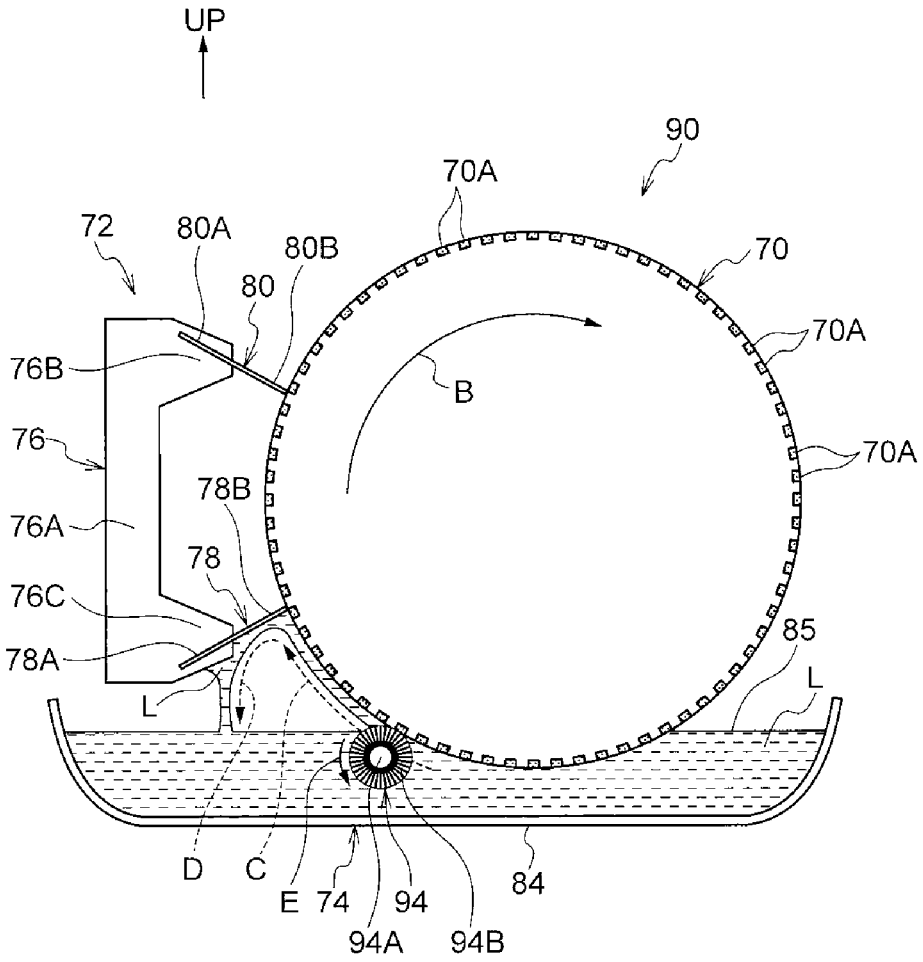
78A
L
L
D
C
74
86
84

FIG. 6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70
70A
76B
B
76
70A
78B
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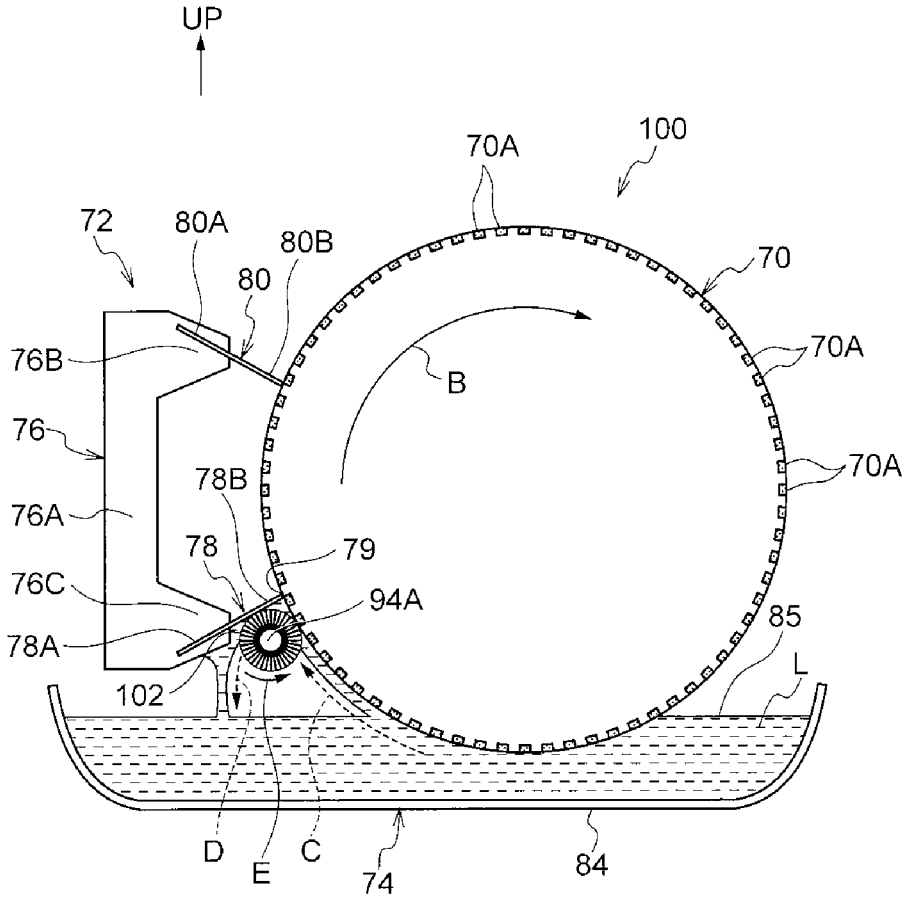
78A
L
L
D
C
E
74
94
84
94A
94B

FIG. 7


UP
100
70A
72
80A
80B
80
70
76B
B
70A
76
78B
70A
76A
78
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76C
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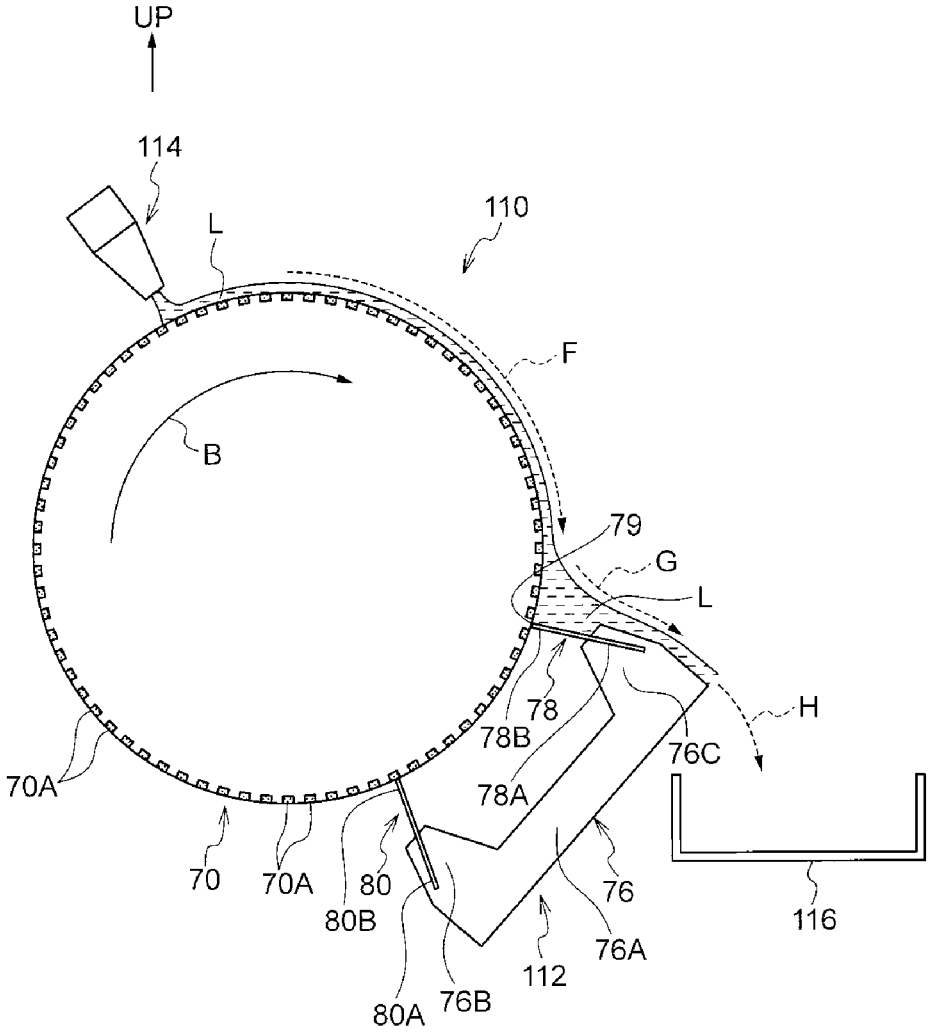
78A
L
102
D
E
C
74
84

FIG. 8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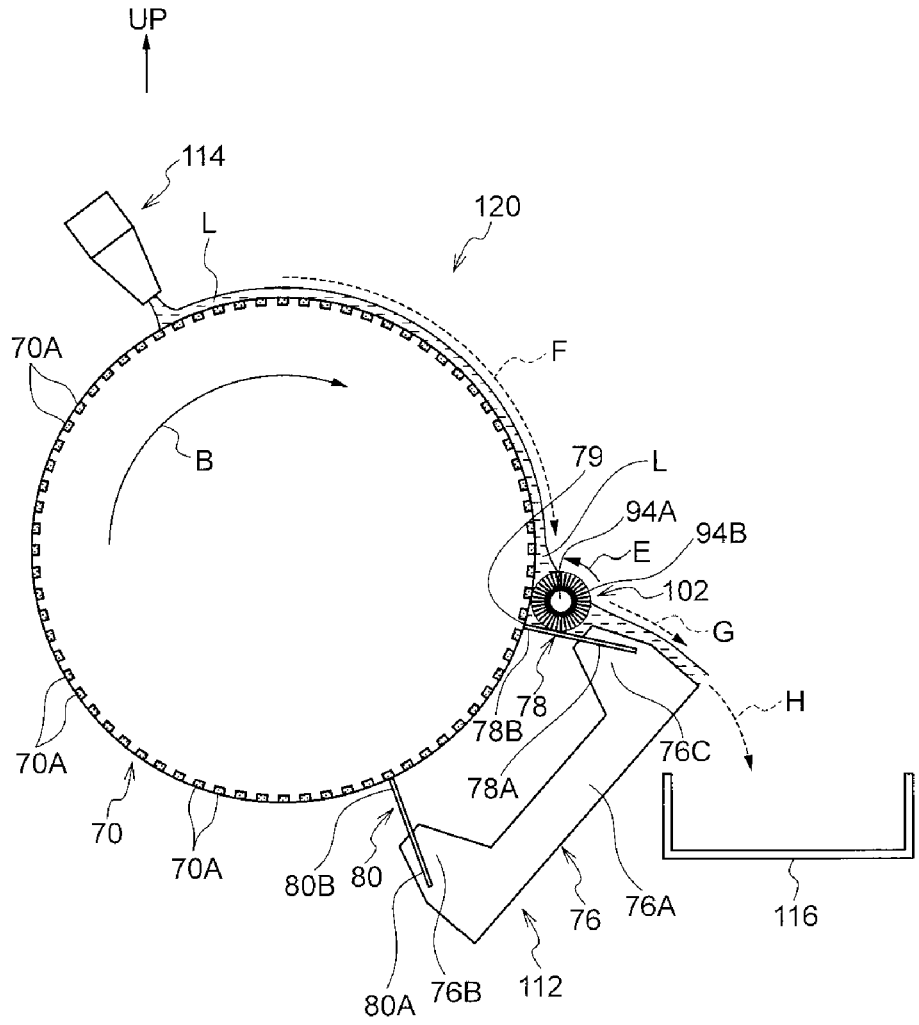
114
L
110
F
B
79
G
L
H
78
78B
78A
76C
70A
70
70A
80
80B
80A
76B
112
76
76A
116

FIG. 9


UP
114
120
L
70A
F
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79
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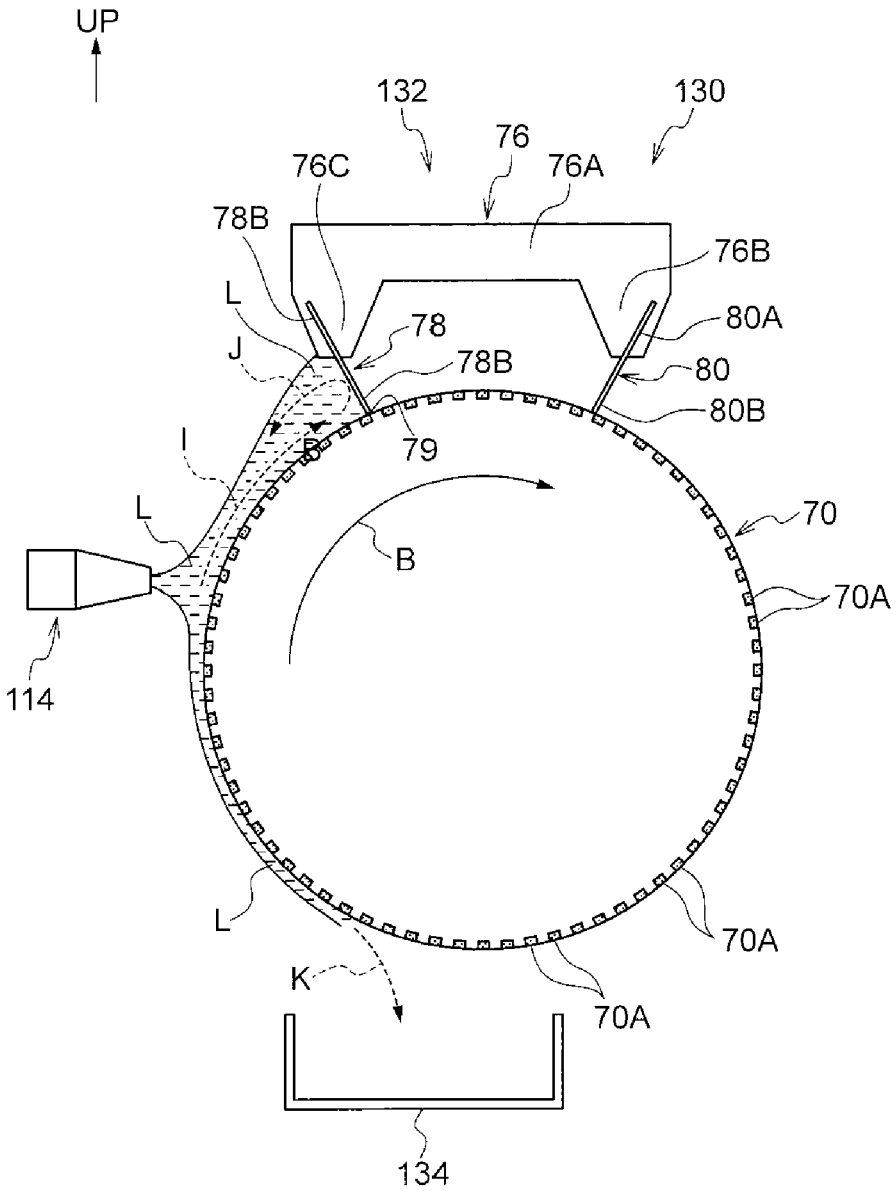
94A
94B
E
102
G
H
78
78B
78A
76C
70A
70
70A
80B
80
80A
76B
112
76
76A
116

FIG. 10


UP
132
130
76
76C
76A
78B
76B
L
78
80A
J
78B
80
80B
I
79
L
70
B
70A
114
L
70A
K
70A
134

LIQUID DEVELOPER SUPPLY DEVICE, DEVELOPING DEVICE, AND IMAGE FORMING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based on and claims priority under 35 USC 119 from Japanese Patent Application No. 2016-026697 filed Feb. 16, 2016.

BACKGROUND

Technical Field

The present invention relates to a liquid developer supply device, a developing device, and an image forming apparatus.

SUMMARY

According to an aspect of the invention, there is provided a liquid developer supply device including:

a supply roller that rotates and holds liquid developer in a recessed portion formed in an outer circumferential surface to supply the liquid developer to a receiving member;

a liquid developer supply unit that supplies liquid developer between a seal member which is in contact with the supply roller on an upstream side in a rotating direction and a regulation member which is in contact with the supply roller on a downstream side, and that forms a liquid developer reservoir; and

a supply unit that supplies a cleaning liquid to a contact portion from an upstream side of the contact portion between the supply roller and the seal member, in the rotating direction of the supply roller, such that the cleaning liquid flows down along the seal member due to gravity.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of the present invention will be described in detail based on the following figures, wherein:

FIG. **1** is a view showing a configuration of an image forming apparatus including a liquid developer supply device according to a first exemplary embodiment of the invention;

FIG. **2** is a view showing a configuration of the liquid developer supply device and a developing device which are used in the image forming apparatus shown in FIG. **1**;

FIG. **3** is a view showing a configuration of the liquid developer supply device shown in FIG. **2** and showing a state when an image is formed;

FIG. **4** is a view showing a configuration of a cleaning process in the liquid developer supply device shown in FIG. **3**;

FIG. **5** is a view showing a configuration of the cleaning process of the liquid developer supply device shown in FIG. **3** and showing a state during cleaning;

FIG. **6** is a view showing a configuration of the liquid developer supply device of a second exemplary embodiment in a state in which cleaning is performed;

FIG. **7** is a view showing a configuration of the liquid developer supply device of a third exemplary embodiment in a state in which cleaning is performed;

FIG. **8** is a view showing a configuration of the liquid developer supply device of a fourth exemplary embodiment in a state in which cleaning is performed;

FIG. **9** is a view showing a configuration of the liquid developer supply device of a fifth exemplary embodiment in a state in which cleaning is performed; and

FIG. **10** is a view showing a configuration of the liquid developer supply device of a sixth exemplary embodiment in a state in which cleaning is performed.

DETAILED DESCRIPTION

Hereinafter, exemplary embodiments of an image forming apparatus of the invention will be described with reference to the drawings. Note that arrows UP shown in the drawings represent an upper side in a vertical direction of the apparatus.

First Exemplary Embodiment

Configuration of Image Forming Apparatus

FIG. **1** shows an example of an image forming apparatus **10** that includes a liquid developer supply device **40** of the first exemplary embodiment. As shown in FIG. **1**, the image forming apparatus **10** includes a transport member (not shown) that transports continuous paper P as an example of a recording medium in a direction of arrow A, an image forming system **14** that forms a toner image on the continuous paper P, and a fixing device **16** that fixes the toner image to the continuous paper P. The image forming system **14** includes an image forming system **14**Y that forms a yellow (Y) toner image, an image forming system **14**M that forms a magenta (M) toner image, an image forming system **14**C that forms a cyan (C) toner image, and an image forming system **14**K that forms a black (K) toner image. In the image forming apparatus **10**, as an example, the image forming systems **14**Y, **14**M, **14**C, and **14**K are arranged in this order from an upstream side in a transport direction of the continuous paper P.

Each of the image forming systems **14**Y, **14**M, **14**C, and **14**K of the respective colors includes an image forming unit **18** that forms a toner image using liquid developer G in which toner and an insulating liquid are contained, and a transfer unit **20** that transfers the toner image formed by the image forming unit **18** to the continuous paper P. In the exemplary embodiment, the continuous paper P is transported by the transport member (not shown) in a lateral direction (direction of the arrow A) and the image forming systems **14**Y, **14**M, **14**C, and **14**K of the respective colors are arranged side by side in the lateral direction.

As shown in FIG. **2**, the image forming unit **18** includes an image holding member **22** that rotates and holds a toner image, a charging device **24** that charges the image holding member **22**, an exposure device **26** that irradiates the image holding member **22** with exposure light so as to form an electrostatic latent image, and a developing device **28** that develops, as a toner image, the electrostatic latent image on the image holding member **22**. Further, the image forming unit **18** is provided with a cleaning device **34** that includes a scraping blade **30** that scrapes, from the image holding member **22**, the liquid developer G remaining on an outer circumferential surface of the image holding member **22** such that no image is transferred to a transfer roller **50**, which will be described below, from the image holding member **22**, and a collecting member **32** that collects the scraped liquid developer G.

The developing device **28** includes a developing roller **36** as an example of a receiving member, which rotates and develops the electrostatic latent image formed on the image holding member **22** with the liquid developer G. In addition,

the developing device **28** includes the liquid developer supply device **40** that supplies the liquid developer G to the developing roller **36**, and a charging device **42** that charges toner contained in the liquid developer G supplied to the developing roller **36**. Further, the developing device **28** is provided with a cleaning device **48** that includes a scraping blade **44** that scrapes, from the developing roller **36**, the liquid developer G remaining on an outer circumferential surface of the developing roller **36** after development, and a collecting member **46** that collects the scraped liquid developer G.

The liquid developer G used in the exemplary embodiment is a liquid type of developer in which toner (particles) is dispersed in a carrier liquid, and as the carrier liquid, an insulating liquid such as vegetable oil, liquid paraffin oil, or silicone oil is used. In addition, an average particle diameter of the toner in the liquid developer G is, as an example, 0.5 μm to 5 μm, and the toner (particles) is dispersed at a concentration of 15 wt % to 45 wt % in the carrier liquid.

In the developing device **28**, the toner contained in the liquid developer G supplied to the outer circumferential surface of the developing roller **36** is charged by the charging device **42** such that the electrostatic latent image on the image holding member **22** is developed as a toner image with the liquid developer G on the outer circumferential surface of the developing roller **36**. Note that, in a case where the electrostatic latent image is developed as the toner image using the liquid developer G, the carrier liquid also migrates to the image holding member **22**.

The transfer unit **20** includes the transfer roller **50** which is rotatably disposed to face the image holding member **22** and to which the toner image on the image holding member **22** is transferred by an electric field formed between the image holding member **22** and the transfer roller **50**. Further, the transfer unit **20** includes a backup roller **52** that is disposed on a side opposite to the transfer roller **50** with the continuous paper P interposed therebetween, and that transfers the toner image on the transfer roller **50** to the continuous paper P by an electric field formed between the transfer roller **50** and the backup roller **52**. Furthermore, the transfer unit **20** is provided with a cleaning device **58** that includes a scraping blade **54** that scrapes, from the transfer roller **50**, the liquid developer G remaining on an outer circumferential surface of the transfer roller **50** after the transfer, and a collecting member **56** that collects the scraped liquid developer G.

In the transfer unit **20**, the toner image on the image holding member **22** is transferred to the transfer roller **50** and the toner image transferred to the transfer roller **50** is transferred to the continuous paper P. Note that the carrier liquid migrating from the developing roller **36** to the image holding member **22** also migrates to the continuous paper P via the transfer roller **50**.

As shown in FIG. **1**, the fixing device **16** includes a heating unit **60** that heats the continuous paper P, a carrier liquid removing unit **62** that removes the carrier liquid from the continuous paper P, and a fixing unit **64** that fixes the toner image to the continuous paper P. Each of the carrier liquid removing unit **62** and the fixing unit **64** includes a heating roller **65** and a pressure roller **66** that presses the continuous paper P against the heating roller **65**.

In the fixing device **16**, the heating unit **60** heats the continuous paper P, the toner and the carrier liquid (oil) contained in the liquid developer G on the continuous paper P are separated from each other, and then an oil layer is formed on the toner. Further, the carrier liquid (oil) is removed by the carrier liquid removing unit **62**, and the continuous paper P is heated and pressurized by the fixing unit **64** such that the toner image is fixed to the continuous paper P.

In the image forming apparatus **10** described above, the image holding member **22** of the image forming units **18** of the respective colors rotates and the outer circumferential surface of the image holding member **22** is charged by the charging device **24**. Next, the outer circumferential surface of the image holding member **22** is exposed by the exposure device **26**, and the electrostatic latent image is formed on the outer circumferential surface of the image holding member **22**. Then, the electrostatic latent image is developed as the toner image by the developing device **28**. Further, the toner image formed on the outer circumferential surface of the rotating image holding member **22** is primarily transferred to the transfer roller **50**. The toner image primarily transferred to the transfer roller **50** is transferred to the continuous paper P which is transported in the direction of the arrow A. This process is performed in the image forming systems **14** of the respective colors, and a toner image, on which the respective colors are superimposed, is formed on the continuous paper P. Further, the carrier liquid (oil) is removed on the transported continuous paper P by the fixing device **16**, and the toner image is fixed to the continuous paper P.

Configuration of Liquid Developer Supply Device

Next, the liquid developer supply device **40** will be described.

FIG. **3** shows a state of the liquid developer supply device **40** of the first exemplary embodiment when an image is formed. As shown in FIG. **3**, the liquid developer supply device **40** includes a supply roller **70** that rotates and holds the liquid developer G so as to supply the liquid developer G to the developing roller **36** (refer to FIG. **2**), and a chamber **72** as an example of a liquid developer supply unit that supplies the liquid developer G to the supply roller **70**. In addition, the liquid developer supply device **40** includes a cleaning liquid supply device **74** as an example of a supply unit that supplies, when cleaning the supply roller **70**, a cleaning liquid L to a contact portion **79** from an upstream side of the contact portion **79** between the supply roller **70** and a seal blade **78** which will be described below (refer to FIG. **5**).

The supply roller **70** is an anilox roller that holds the liquid developer G and supplies the liquid developer G to a contact portion (refer to FIG. **2**) with the developing roller **36**. To be more specific, the supply roller **70** has plural cells **70**A as an example of recessed portions that are arranged in the outer circumferential surface thereof and are recessed to the inner side in a radial direction. The cell **70**A has a volume that may hold the liquid developer G and, with the volume, a pattern of arrangement of the cells **70**A is unlikely to be viewed in the toner image. The cell is, as an example, about 12 ml (milliliters)/m^2 in volume. Note that FIG. **3** is a schematic view showing the plural rectangular cells **70**A arranged in the outer circumferential surface of the supply roller **70** at intervals; however, in reality, the supply roller **70** has the cells **70**A which are smaller in size and the cells **70**A are arranged at narrower intervals.

The chamber **72** includes a storage member **76** that stores the liquid developer G, the seal blade **78** as an example of a seal member that is disposed on an upstream side in a rotating direction (direction of arrow B) of the supply roller **70**, and a regulation blade (doctor blade) **80** as an example of a regulation member which is disposed on a downstream side in the rotating direction of the supply roller **70**. The chamber **72** is disposed in a region in which the supply roller

70 rotates in the rotating direction (direction of the arrow B) from the lower side in the vertical direction toward the upper side in the vertical direction.

The storage member **76** is formed to have a box shape which is opened toward the supply roller **70** side. The storage member **76** is disposed to have the longitudinal direction thereof is matched with an axial direction of the supply roller **70**. To be more specific, the storage member **76** has a side portion **76**A disposed to face a circumferential surface of the supply roller **70** in a cross-sectional view, a downstream-side protruding portion **76**B that protrudes from one end portion (end portion on the downstream side in the rotating direction of the supply roller **70**) of the side portion **76**A toward the supply roller **70** side, and an upstream-side protruding portion **76**C that protrudes from the other end portion (end portion on the upstream side in the rotating direction of the supply roller **70**) of the side portion **76**A toward the supply roller **70** side. In the exemplary embodiment, the side portion **76**A of the storage member **76** is disposed in the vertical direction, the downstream-side protruding portion **76**B is disposed at an upper end portion of the side portion **76**A, and the upstream-side protruding portion **76**C is disposed at a lower end portion of the side portion **76**A. Each of the downstream-side protruding portion **76**B and the upstream-side protruding portion **76**C is formed to have a trapezoidal shape of which a length in the vertical direction is reduced toward the supply roller **70** side.

A base end portion **78**A of the seal blade **78** is supported in the upstream-side protruding portion **76**C of the storage member **76**. A front end portion **78**B of the seal blade **78** is in contact with the outer circumferential surface of the supply roller **70**, and the contact portion **79** is formed between the front end portion **78**B of the seal blade **78** and the supply roller **70**. The seal blade **78** is disposed to be inclined such that the front end portion **78**B is disposed on the upper side from the base end portion **78**A in the vertical direction. In other words, the seal blade **78** is disposed so as to be sloped downward to the base end portion **78**A side from the front end portion **78**B that is in contact with the supply roller **70**. The front end portion **78**B of the seal blade **78** is in contact with the supply roller **70** in a direction toward the downstream side in the rotating direction (direction of the arrow B) of the supply roller **70**. The seal blade **78** is formed of, as an example, metal such as stainless steel.

A base end portion **80**A of the regulation blade **80** is supported in the downstream-side protruding portion **76**B of the storage member **76**, and a front end portion **80**B of the regulation blade **80** is in contact with the outer circumferential surface of the supply roller **70**. The regulation blade **80** is disposed to be inclined such that the front end portion **80**B is disposed on the lower side from the base end portion **80**A in the vertical direction. In other words, the regulation blade **80** is disposed so as to be sloped upward to the base end portion **80**A side from the front end portion **80**B that is in contact with the supply roller **70**. The front end portion **80**B of the regulation blade **80** is in contact with the supply roller **70** in a direction toward the upstream side in the rotating direction (direction of the arrow B) of the supply roller **70**. The regulation blade **80** is formed of, as an example, metal such as stainless steel.

A supply tube (not shown), which supplies the liquid developer G from a storage tank (not shown) into the inner side of the storage member **76** using a pump, is connected to a lower portion of the side portion **76**A of the storage member **76**. In this manner, the liquid developer G flows into a portion surrounded by the storage member **76**, the seal blade **78**, and the regulation blade **80**, and a liquid developer reservoir **81** is formed in the inside (in the exemplary embodiment, the seal blade **78** side on the lower side in the vertical direction) of the chamber **72**. Note that a surplus of liquid developer G in the chamber **72** is discharged through a discharge tube (not shown) disposed on the upper side of the side portion **76**A of the storage member **76** to the outside of the chamber **72**.

The cleaning liquid supply device **74** has a function of supplying the cleaning liquid L to the contact portion **79** from the upstream side of the contact portion **79** between the supply roller **70** and the seal blade **78** in the rotating direction of the supply roller **70**, when the liquid developer supply device **40** is cleaned in a process different from the process executed when the image is formed. A cleaning process of the liquid developer supply device **40** is performed, as an example, after the image is formed or a predetermined period of time elapses after the image is formed. As shown in FIG. **4**, the cleaning liquid supply device **74** includes a cleaning vessel **84** that is disposed on the lower side of the supply roller **70** and stores the cleaning liquid L. The cleaning vessel **84** is formed to have a bowl shape so as to surround an outer circumferential surface of the supply roller **70** on the lower side. In addition, the cleaning vessel **84** extends to a position so as to be disposed on the lower side from the chamber **72**. A supply tube (not shown), which supplies the cleaning liquid L from the storage tank (not shown) to the inside of the cleaning vessel **84** using a pump, is connected to a bottom wall of the cleaning vessel **84**.

As the cleaning liquid L, as an example, a carrier liquid that forms the liquid developer, or an organic solvent, in which any of isopropyl alcohol or acetone is contained, is used.

As shown in FIG. **4**, the cleaning liquid L is supplied into the inside of the cleaning vessel **84** and, thereby, a cleaning liquid reservoir portion **85** is formed in the inside of the cleaning vessel **84**. In this manner, a lower portion of the supply roller **70** as an example of a part of the supply roller **70** is immersed into the cleaning liquid reservoir portion **85**. The lower portion of the supply roller **70** is immersed into the cleaning liquid reservoir portion **85** of the cleaning vessel **84** at a position on the upstream side of the contact portion **79** between the supply roller **70** and the seal blade **78** in the rotating direction (direction of the arrow B) of the supply roller **70** (refer to FIG. **5**). In other words, the seal blade **78** is disposed in a range in which the supply roller **70** moves upward from the cleaning liquid reservoir portion **85** of the cleaning vessel **84** (refer to FIG. **5**).

In the exemplary embodiment, the seal blade **78** is disposed on the lower side from the central portion of the supply roller **70** in the vertical direction. In addition, the seal blade **78** is disposed such that a surface thereof on the side opposite to the liquid developer reservoir **81** (refer to FIG. **3**) is directed downward.

As shown in FIG. **5**, when the supply roller **70** is caused to rotate in the direction of the arrow B, the cleaning liquid L is attached to the outer circumferential surface of the supply roller **70** and is brought along in the direction of arrow C due to the rotation of the supply roller **70** (in the state of being attached to the outer circumferential surface of the supply roller **70**). In this manner, the cleaning liquid L is supplied to the contact portion **79** from the upstream side of the contact portion **79** between the supply roller **70** and the seal blade **78**. Then, since the seal blade **78** is disposed to be sloped downward from the front end portion **78**B to the base end portion **78**A, the cleaning liquid L supplied to the contact portion **79** flows down along the seal blade **78** due

to gravity (flows down along the lower surface of the seal blade **78**). The cleaning vessel **84** is disposed at a position at which the cleaning liquid L after flowing down along the seal blade **78** is received, and thus, the cleaning liquid L after flowing down is collected in the cleaning vessel **84**.

In addition, a discharge tube (not shown), through which the cleaning liquid L is discharged, is connected to a bottom wall of the cleaning vessel **84**, and an on-off valve (not shown) is provided in the discharge tube. In the exemplary embodiment, as an example, the on-off valve is closed in the cleaning process such that the cleaning liquid L is supplied to the cleaning vessel **84**. In addition, in the exemplary embodiment, as an example, the on-off valve is opened after the cleaning process such that the cleaning liquid L is discharged from the cleaning vessel **84**.

An ultrasonic oscillator **86** as an example of a replacement portion is provided in a lower portion of the cleaning vessel **84**. The ultrasonic oscillator **86** is provided with an ultrasonic vibrator (not shown) that generates an ultrasonic wave and drives the ultrasonic vibrator, and thereby, the cleaning liquid L in the inside of the cleaning vessel **84** vibrates due to the ultrasonic wave and then, multiple fine bubbles are formed in the cleaning liquid L. The multiple fine bubbles in the cleaning liquid L collide with the outer circumferential surface of the supply roller **70** such that the liquid developer G in the cell **70**A of the supply roller **70** is replaced with the cleaning liquid L.

Operation and Effect

Next, operations and effects of the exemplary embodiment will be described.

As shown in FIG. **3**, when an image is formed, in the liquid developer supply device **40**, the supply roller **70** rotates in the direction of the arrow B, the supply roller **70** comes into contact with the liquid developer reservoir **81** inside the chamber **72**, and thereby the liquid developer G is supplied to the outer circumferential surface of the supply roller **70**. Further, the outer circumferential surface of the supply roller **70** passes the contact portion with the regulation blade **80**, thereby the surplus of the liquid developer G on the outer circumferential surface of the supply roller **70** is scraped, and the liquid developer G is held in the cell **70**A of the supply roller **70**. As shown in FIG. **2**, the supply roller **70** is in contact with the developing roller **36**, and the developing roller **36** rotates at a contact position with the supply roller **70** in the same direction as the supply roller. In this manner, the liquid developer G held in the cell **70**A of the supply roller **70** is supplied to the developing roller **36**. Then, the image is formed on the continuous paper P through a series of image forming processes of the image forming apparatus **10** (refer to FIG. **1**).

In the liquid developer supply device **40**, the cleaning process of cleaning the contact portion **79** between the supply roller **70** and the seal blade **78** is executed after the image is formed or after a predetermined period of time elapses after the image is formed. As shown in FIG. **4**, in a state in which the rotation of the supply roller **70** is stopped, the on-off valve (not shown) of the cleaning vessel **84** is closed, and the cleaning liquid L is supplied to the inside of the cleaning vessel **84** through the supply tube (not shown). In this manner, the cleaning liquid reservoir portion **85** is formed inside the cleaning vessel **84**, and the lower portion of the supply roller **70** is immersed into the cleaning liquid reservoir portion **85**.

In this state, as shown in FIG. **5**, when the supply roller **70** is caused to rotate in the direction of the arrow B, the cleaning liquid L is attached to the outer circumferential surface of the supply roller **70** with the rotation of the supply roller **70** and is brought along in the direction of arrow C. In this manner, the cleaning liquid L is supplied to the contact portion **79** from the upstream side of the contact portion **79** between the supply roller **70** and the seal blade **78**. Therefore, the upstream side of the contact portion **79** between the supply roller **70** and the seal blade **78** in the rotating direction (direction of the arrow B) of the supply roller **70** is cleaned with the cleaning liquid L, and an attached substance such as the high-concentration liquid developer attached on the upstream side of the contact portion **79** between the supply roller **70** and the seal blade **78** is removed.

In addition, the seal blade **78** is disposed to be sloped downward from the front end portion **78**B to the base end portion **78**A side. Therefore, the cleaning liquid L supplied to the upstream side of the contact portion **79** between the supply roller **70** and the seal blade **78** flows down along the seal blade **78** in a direction represented by arrow D due to gravity. In other words, the cleaning liquid L flows down along the lower surface of the seal blade **78** due to gravity. The cleaning liquid L flowing down along the lower surface of the seal blade **78** due to gravity is collected in the cleaning vessel **84**.

In addition, the ultrasonic oscillator **86** is provided in the cleaning vessel **84**, the cleaning liquid L of the cleaning liquid reservoir portion **85** inside the cleaning vessel **84** vibrates with the ultrasonic wave, and multiple fine bubbles are formed in the cleaning liquid L. The multiple fine bubbles in the cleaning liquid L collide with the outer circumferential surface of the supply roller **70** such that the liquid developer G in the cell **70**A of the supply roller **70** is replaced with the cleaning liquid L.

In the liquid developer supply device **40** of the exemplary embodiment, the high-concentration liquid developer accumulated in the contact portion **79** between the supply roller and the seal blade **78** is removed such that the high-concentration liquid developer enters into the chamber **72**, as compared with a configuration which does not include the cleaning liquid supply device that supplies the cleaning liquid to the contact portion between the supply roller and the seal blade such that the cleaning liquid flows down along the seal blade due to gravity.

In addition, in the liquid developer supply device **40**, the liquid developer G in the cell **70**A of the supply roller **70** is more likely to be replaced with the cleaning liquid L such that the cleaning efficiency is improved, as compared with a configuration which does not include, below the supply roller, the cleaning liquid reservoir portion into which a part of the supply roller is immersed.

Further, in the liquid developer supply device **40**, the liquid developer G in the cell **70**A of the supply roller **70** is more efficiently replaced with the cleaning liquid (replacement of the liquid developer G by the cleaning liquid L is promoted) such that the cleaning efficiency is still more improved, as compared with a configuration which does not include the ultrasonic oscillator **86** in the cleaning vessel **84**.

Second Exemplary Embodiment

Next, a liquid developer supply device as the second exemplary embodiment of the invention will be described with reference to FIG. **6**. Note that the same reference signs are assigned to the same components as those in the first exemplary embodiment, and description thereof is omitted.

As shown in FIG. **6**, a liquid developer supply device **90** includes the cleaning liquid supply device **74** below the supply roller **70**. In the cleaning liquid supply device **74**,

instead of the ultrasonic oscillator **86** of the first exemplary embodiment, a brush **94** as an example of the replacement portion is disposed in the inside of the cleaning vessel **84** so as to be in contact with the outer circumferential surface of the supply roller **70**. The brush **94** has a shaft **94**A that is rotatably supported in a support member (not shown) provided in the cleaning vessel **84**, and multiple brush bristles **94**B provided around the shaft **94**A. The brush bristle **94**B has, as an example, a length which is sufficient for a front end of the brush bristle **94**B to come into contact with an inner wall of the cell **70**A of the supply roller **70**. In addition, the brush **94** is configured to rotate in a direction of arrow E along with the rotation of the supply roller **70**.

The brush **94** is disposed to be immersed into the cleaning liquid reservoir portion **85** in the cleaning vessel **84** with the entirety or a part of the brush left without being immersed. In the exemplary embodiment, the brush **94** is disposed to be in contact with the outer circumferential surface of the supply roller **70** at a position at which the supply roller **70** emerges from the cleaning liquid reservoir portion **85** of the cleaning vessel **84** with the rotation of the supply roller **70**.

In the liquid developer supply device **90**, the brush **94**, which is immersed in the cleaning liquid reservoir portion **85** in the cleaning vessel **84**, rotates in contact with the outer circumferential surface of the supply roller **70**. Therefore, the liquid developer G in the cell **70**A of the supply roller **70** is more efficiently replaced with the cleaning liquid L (replacement of the liquid developer G by the cleaning liquid L is promoted) such that the cleaning efficiency is improved, as compared with a configuration which does not include the brush in the cleaning liquid reservoir portion **85** in the cleaning vessel **84**.

Third Exemplary Embodiment

Next, a liquid developer supply device as the third exemplary embodiment of the invention will be described with reference to FIG. **7**. Note that the same reference signs are assigned to the same components as those in the first and second exemplary embodiments, and description thereof is omitted.

As shown in FIG. **7**, a liquid developer supply device **100** includes the cleaning liquid supply device **74** below the supply roller **70**. In the cleaning liquid supply device **74**, instead of the brush **94** of the second exemplary embodiment, a brush **102** as an example of the replacement portion is provided at a position at which the cleaning liquid L supplied to the supply roller **70** comes into contact with the supply roller. The brush **102** is provided at the position at which the seal blade **78** is in contact with the outer circumferential surface of the supply roller **70**, on the upstream side of the contact portion **79** between the supply roller **70** and the seal blade **78** in the rotating direction (direction of the arrow B) of the supply roller **70**. The brush **102** is rotatably supported to rotate in the direction of arrow E along with the rotation of the supply roller **70**.

In the liquid developer supply device **100**, the brush **102** is disposed on the upstream side of the contact portion **79** between the supply roller **70** and the seal blade **78** in the rotating direction of the supply roller **70**, and the brush **102** rotates in contact with the outer circumferential surface of the supply roller **70** and the seal blade **78**. Therefore, the liquid developer G in the cell **70**A of the supply roller **70** is more efficiently replaced with the cleaning liquid L (replacement of the liquid developer G by the cleaning liquid L is promoted) such that the cleaning efficiency is improved, as compared with a configuration which does not include the brush at the position at which the cleaning liquid supplied to the supply roller comes into contact with the supply roller. In this manner, the attached substance such as the high-concentration liquid developer attached on the supply roller **70** or the seal blade **78**, or the attached substance such as the high-concentration liquid developer attached in the vicinity of the contact portion **79** between the supply roller **70** and the seal blade **78** is removed.

Fourth Exemplary Embodiment

Next, a liquid developer supply device as the fourth exemplary embodiment of the invention will be described with reference to FIG. **8**. Note that the same reference signs are assigned to the same components as those in the first to third exemplary embodiments, and description thereof is omitted.

As shown in FIG. **8**, a liquid developer supply device **110** includes a chamber **112** as an example of a liquid developer supply unit, which is disposed at a position facing an obliquely lower side of the supply roller **70**, and a nozzle **114** as an example of an ejection portion through which the cleaning liquid L is ejected to the supply roller **70** on the upstream side of the chamber **112** in the rotating direction of the supply roller **70**.

The chamber **112** includes the storage member **76**, the seal blade **78**, and the regulation blade **80**. In the exemplary embodiment, the side portion **76**A of the storage member **76** is disposed to be inclined at a position facing an outer circumferential surface on the obliquely lower side of the supply roller **70**. The downstream-side protruding portion **763**, in which the regulation blade **80** is supported, is disposed on the lower end portion of the side portion **76**A, and the upstream-side protruding portion **76**C, in which the seal blade **78** is supported, is disposed on the upper end portion of the side portion **76**A.

The seal blade **78** is disposed in a range in which the supply roller **70** moves downward. In other words, the front end portion **78**B of the seal blade **78** is in contact with the supply roller **70** in the range in which the supply roller **70** moves downward. The seal blade **78** is disposed to be sloped downward from the front end portion **78**B to the base end portion **78**A. In the exemplary embodiment, the seal blade **78** is disposed below the central portion of the supply roller **70** in the vertical direction. In addition, in the exemplary embodiment, a liquid developer reservoir (not shown) is formed on the lower side of the chamber **112** on the regulation blade **80** side, and the seal blade **78** is disposed such that a surface thereof on the side opposite to the liquid developer reservoir (not shown) is directed downward. In addition, a collection member **116**, in which the cleaning liquid L after flowing down along the seal blade **78** due to gravity is collected, is provided below the side (back surface side) of the storage member **76** opposite to the supply roller **70**.

The nozzle **114** is disposed in the longitudinal direction of the supply roller **70** and the cleaning liquid L is continuously ejected through the nozzle to the rotating supply roller **70**, thereby having a function of supplying the cleaning liquid L to the outer circumferential surface of the supply roller **70**. A supply tube (not shown), through which the cleaning liquid L is supplied from the storage tank (not shown) using a pump, is connected to the nozzle **114**.

The nozzle **114** is disposed on the upper side from the seal blade **78** in the vertical direction. The nozzle **114** is an example of a supply unit such that the cleaning liquid L is supplied to the contact portion **79** from the upstream side of

the contact portion **79** between the supply roller **70** and the seal blade **78** in the rotating direction of the supply roller **70**.

In the liquid developer supply device **110**, the cleaning liquid L is ejected through the nozzle **114** to the rotating supply roller **70**, and thereby the cleaning liquid L supplied to the outer circumferential surface of the supply roller **70** with the rotation of the supply roller **70** moves in a direction of arrow F. In this manner, the cleaning liquid L is supplied to the contact portion **79** between the supply roller **70** and the seal blade **78**. Therefore, the contact portion **79** between the supply roller **70** and the seal blade **78** is cleaned with the cleaning liquid L, and the attached substance such as the high-concentration liquid developer accumulated on the upstream side of the contact portion **79** between the supply roller **70** and the seal blade **78** is removed. Further, the cleaning liquid L flows down along the seal blade **78** in a direction represented by arrow G due to gravity. In other words, the cleaning liquid L flows down along the top surface of the seal blade **78** due to gravity. The cleaning liquid L after flowing down along the top surface of the seal blade **78** due to gravity flows along the top surface of the storage member **76** and is collected in the collection member **116** on the back surface side of the storage member **76**, in a direction represented by arrow H.

In the liquid developer supply device **110**, high-concentration liquid developer accumulated in the contact portion **79** between the supply roller **70** and the seal blade **78** is removed such that the high-concentration liquid developer enters into the inside of the chamber **72**, as compared with a configuration which does not include the supply unit that supplies the cleaning liquid to the contact portion between the supply roller and the seal blade such that the cleaning liquid flows down along the seal blade due to gravity. In addition, flexibility in selection of a position, at which the cleaning liquid L is supplied to the supply roller **70**, is improved, as compared with a configuration which does not include the nozzle through which the cleaning liquid is ejected to the supply roller.

Further, the cleaning liquid L used in cleaning the contact portion **79** between the seal blade **78** and the supply roller **70** mixes with the cleaning liquid L ejected from the nozzle **114**, as compared with a configuration in which the nozzle is disposed below the seal blade.

Fifth Exemplary Embodiment

Next, a liquid developer supply device as the fifth exemplary embodiment of the invention will be described with reference to FIG. **9**. Note that the same reference signs are assigned to the same components as those in the first to fourth exemplary embodiments, and description thereof is omitted.

As shown in FIG. **9**, a liquid developer supply device **120** includes the brush **102** as an example of the replacement portion, which is provided at a position at which the cleaning liquid L supplied to the supply roller **70** comes into contact with the supply roller. The brush **102** is provided at the position at which the seal blade **78** is in contact with the outer circumferential surface of the supply roller **70**, on the upstream side of the contact portion **79** between the supply roller **70** and the seal blade **78** in the rotating direction (direction of the arrow B) of the supply roller **70**. The brush **102** rotates in the direction of the arrow E along with the rotation of the supply roller **70**.

In the liquid developer supply device **120**, the liquid developer G in the cell **70**A of the supply roller **70** is more efficiently replaced with the cleaning liquid L (replacement of the liquid developer G by the cleaning liquid L is promoted) such that the cleaning efficiency is improved, as compared with a configuration which does not include the brush at the position at which the cleaning liquid supplied to the supply roller comes into contact with the supply roller. In this manner, the attached substance such as the high-concentration liquid developer attached on the supply roller **70** or the seal blade **78**, or the attached substance such as the high-concentration liquid developer attached in the vicinity of the contact portion **79** between the supply roller **70** and the seal blade **78** is removed.

Note that the position of the brush **102** is not limited to that in the exemplary embodiment, but may be changed as long as the cleaning liquid L supplied to the supply roller **70** comes into contact with the supply roller at the position.

Sixth Exemplary Embodiment

Next, a liquid developer supply device as the sixth exemplary embodiment of the invention will be described with reference to FIG. **10**. Note that the same reference signs are assigned to the same components as those in the first to fifth exemplary embodiments, and description thereof is omitted.

As shown in FIG. **10**, a liquid developer supply device **130** includes a chamber **132** as an example of the liquid developer supply unit, which is disposed at a position facing an upper portion of the supply roller **70**, and the nozzle **114** as an example of the ejection portion through which the cleaning liquid L is ejected to the supply roller **70** on the upstream side of the chamber **132** in the rotating direction of the supply roller **70**.

The chamber **132** includes the storage member **76**, the seal blade **78**, and the regulation blade **80**. In the exemplary embodiment, the side portion **76**A of the storage member **76** is disposed in a lateral direction so as to intersect with the axial direction of the supply roller **70** at a position facing an outer circumferential surface on the upper side of the supply roller **70**. The seal blade **78** is disposed to be sloped down from the base end portion **78**A to the front end portion **78**B side. In the exemplary embodiment, the seal blade **78** is disposed such that a surface thereof on the side opposite to the liquid developer reservoir (not shown) which is formed in the chamber **132** is directed downward.

The nozzle **114** is disposed on the lower side from the seal blade **78** in the vertical direction such that the cleaning liquid L is supplied to the contact portion **79** from the upstream side of the contact portion **79** between the supply roller **70** and the seal blade **78** in the rotating direction of the supply roller **70**. In addition, a collection member **134**, in which the cleaning liquid L after flowing over the seal blade **78** due to gravity and farther flowing down along the outer circumferential surface of the supply roller **70** is collected, is provided below the supply roller **70**.

In the liquid developer supply device **130**, the cleaning liquid L is ejected through the nozzle **114** to the rotating supply roller **70**, and thereby the cleaning liquid L supplied to the outer circumferential surface of the supply roller **70** with the rotation of the supply roller **70** moves in a direction of arrow I. In this manner, the cleaning liquid L is supplied to the contact portion **79** between the supply roller **70** and the seal blade **78**. Therefore, the contact portion **79** between the supply roller **70** and the seal blade **78** is cleaned with the cleaning liquid L, and the attached substance such as the high-concentration liquid developer accumulated on the upstream side of the contact portion **79** between the supply roller **70** and the seal blade **78** is removed. Further, the cleaning liquid L supplied to the contact portion **79** between

the supply roller **70** and the seal blade **78** is once diverted to the upper side of the seal blade **78** due to the fluid pressure of the cleaning liquid L in the direction of the arrow I and flows down to the outer circumferential surface side of the supply roller **70** along the seal blade **78** in a direction represented by arrow J due to gravity. Furthermore, the cleaning liquid L flows down along the outer circumferential surface of the supply roller **70** due to gravity and then, is collected in the collection member **134** disposed below the supply roller **70** in a direction represented by arrow K.

In the liquid developer supply device **130**, high-concentration liquid developer accumulated in the contact portion **79** between the supply roller **70** and the seal blade **78** is removed such that the high-concentration liquid developer enters into the inside of the chamber **72**, as compared with a configuration which does not include the supply unit that supplies the cleaning liquid to the contact portion between the supply roller and the seal blade such that the cleaning liquid flows down along the seal blade due to gravity. In addition, flexibility in selection of a position, at which the cleaning liquid L is supplied to the supply roller **70**, is improved, as compared with a configuration which does not include the nozzle through which the cleaning liquid is ejected to the supply roller.

Note that, in the first to sixth exemplary embodiments, the plural cells **70**A are provided in the outer circumferential surface of the supply roller **70**; however, the invention is not limited to the configurations described above. For example, a configuration, in which plural grooves as an example of the recessed portion are provided on the outer circumferential surface of the supply roller **70**, may be employed.

In addition, in the fourth to sixth exemplary embodiments, the nozzle **114**, through which the cleaning liquid L is ejected to the supply roller **70**, is used; however, the invention is not limited to the configurations. For example, a cleaning liquid supply member such as a roller, which supplies the cleaning liquid L to the supply roller **70**, may be provided.

In addition, the second, third, or fifth exemplary embodiment has a configuration in which the brush that is in contact with the supply roller **70** rotates along with the rotation of the supply roller **70**; however, the invention is not limited to this configuration. For example, the brush may be configured to be rotated and driven separately from the supply roller **70**, and the brush may be rotated in an opposite direction thereto at the position at which the brush is in contact with the supply roller **70**.

In addition, in the second and third exemplary embodiments, the brush is provided as an example of the replacement portion; however, the invention is not limited thereto. For example, a configuration, in which the brush and the ultrasonic oscillator provided in the cleaning vessel are together used, may be employed.

The foregoing description of the exemplary embodiments of the present invention has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Obviously, many modifications and variations will be apparent to practitioners skilled in the art. The embodiments were chosen and described in order to best explain the principles of the invention and its practical applications, thereby enabling others skilled in the art to understand the invention for various embodiments and with the various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the following claims and their equivalents.

What is claimed is:

1. A liquid developer supply device comprising:

a supply roller that rotates and holds liquid developer in a recessed portion formed in an outer circumferential surface to supply the liquid developer to a receiving member;

a liquid developer supply unit that supplies liquid developer between a seal member which is in contact with the supply roller on an upstream side in a rotating direction and a regulation member which is in contact with the supply roller on a downstream side, and that forms a liquid developer reservoir; and

a supply unit that supplies a cleaning liquid to a contact portion from an upstream side of the contact portion between the supply roller and the seal member, in the rotating direction of the supply roller, such that the cleaning liquid flows down along the seal member due to gravity so as to reach a point distant from the supply roller.

2. The liquid developer supply device according to claim **1**,

wherein the supply unit includes an ejection portion that ejects the cleaning liquid to the supply roller at a position facing the supply roller.

3. The liquid developer supply device according to claim **2**,

wherein the ejection portion is disposed on an upper side of the seal member in a vertical direction, and

wherein the seal member is disposed in a range in which the supply roller moves downward.

4. The liquid developer supply device according to claim **3**, further comprising:

a replacement portion that is provided at a position at which the replacement portion is in contact with the cleaning liquid supplied to the supply roller, and that causes liquid developer in the recessed portion of the supply roller to be replaced with the cleaning liquid.

5. A developing device comprising:

the liquid developer supply device according to claim **3**,

wherein the receiving member is a developing roller that rotates in contact with the supply roller and that holds liquid developer.

6. The liquid developer supply device according to claim **2**, further comprising:

a replacement portion that is provided at a position at which the replacement portion is in contact with the cleaning liquid supplied to the supply roller, and that causes liquid developer in the recessed portion of the supply roller to be replaced with the cleaning liquid.

7. A developing device comprising:

the liquid developer supply device according to claim **2**,

wherein the receiving member is a developing roller that rotates in contact with the supply roller and that holds liquid developer.

8. The liquid developer supply device according to claim **1**, further comprising:

a replacement portion that is provided at a position at which the replacement portion is in contact with the cleaning liquid supplied to the supply roller, and that causes liquid developer in the recessed portion of the supply roller to be replaced with the cleaning liquid.

9. A developing device comprising:

the liquid developer supply device according to claim **8**,

wherein the receiving member is a developing roller that rotates in contact with the supply roller and that holds liquid developer.

10. A developing device comprising:
the liquid developer supply device according to claim 1,
wherein the receiving member is a developing roller that rotates in contact with the supply roller and that holds liquid developer.

11. An image forming apparatus comprising:
the developing device according to claim 10; and
an image holding member that has a surface on which a latent image is formed so that the developing device develops the latent image.

12. A liquid developer supply device comprising:
a supply roller that rotates and holds liquid developer in a recessed portion formed in an outer circumferential surface to supply the liquid developer to a receiving member;
a liquid developer supply unit that supplies liquid developer between a seal member which is in contact with the supply roller on an upstream side in a rotating direction and a regulation member which is in contact with the supply roller on a downstream side, and that forms a liquid developer reservoir; and
a supply unit that supplies a cleaning liquid to a contact portion from an upstream side of the contact portion between the supply roller and the seal member, in the rotating direction of the supply roller, such that the cleaning liquid flows down along the seal member due to gravity,
wherein the supply unit immerses a part of the supply roller into a cleaning liquid reservoir portion disposed below the supply roller to supply the cleaning liquid to the contact portion with the rotation of the supply roller, and
wherein the seal member is disposed in a range in which the supply roller moves upward from the cleaning liquid reservoir portion.

13. The liquid developer supply device according to claim 12,
wherein the cleaning liquid reservoir portion is provided with a replacement portion that causes liquid developer in the recessed portion of the supply roller to be replaced with the cleaning liquid.

14. The liquid developer supply device according to claim 13, further comprising:
a replacement portion that is provided at a position at which the replacement portion is in contact with the cleaning liquid supplied to the supply roller, and that causes liquid developer in the recessed portion of the supply roller to be replaced with the cleaning liquid.

15. A developing device comprising:
the liquid developer supply device according to claim 13,
wherein the receiving member is a developing roller that rotates in contact with the supply roller and that holds liquid developer.

16. The liquid developer supply device according to claim 12, further comprising:
a replacement portion that is provided at a position at which the replacement portion is in contact with the cleaning liquid supplied to the supply roller, and that causes liquid developer in the recessed portion of the supply roller to be replaced with the cleaning liquid.

17. A developing device comprising:
the liquid developer supply device according to claim 12,
wherein the receiving member is a developing roller that rotates in contact with the supply roller and that holds liquid developer.

18. An image forming apparatus comprising:
the developing device according to claim 17; and
an image holding member that has a surface on which a latent image is formed so that the developing device develops the latent image.

19. A liquid developer supply device comprising:
a supply roller that rotates and holds liquid developer in a recessed portion formed in an outer circumferential surface to supply the liquid developer to a receiving member;
a liquid developer supply unit that supplies liquid developer between a seal member which is in contact with the supply roller on an upstream side in a rotating direction and a regulation member which is in contact with the supply roller on a downstream side, and that forms a liquid developer reservoir;
a supply unit that supplies a cleaning liquid to a contact portion from an upstream side of the contact portion between the supply roller and the seal member, in the rotating direction of the supply roller, such that the cleaning liquid flows down along the seal member due to gravity; and
a replacement portion that is provided at a position at which the replacement portion is in contact with the cleaning liquid supplied to the supply roller, and that causes liquid developer in the recessed portion of the supply roller to be replaced with the cleaning liquid,
wherein the replacement portion includes a brush that is provided to rotate at a position at which the brush is in contact with the seal member and the supply roller, on the upstream side of the seal member in the rotating direction of the supply roller.

20. A developing device comprising:
the liquid developer supply device according to claim 19,
wherein the receiving member is a developing roller that rotates in contact with the supply roller and that holds liquid developer.

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